IN THE SPECIFICATION:

Paragraph beginning on page 5, line 29.

Figs. ~~1 depicts a template positioned over a substrate for electric field based lithography using UV curable compositions~~ 1A-1E illustrate a version of the imprint lithography process according to the invention;

Paragraph beginning on page 6, line 3.

Fig. 2 ~~depicts a schematic of a process for forming nanoscale structures using direct contact with a template~~ is a process flow diagram showing the sequence of steps of the imprint lithography process of Figs. 1A-1E;

Paragraph beginning on page 6, line 6.

Fig. 3 ~~depicts a schematic of a process for forming nanoscale structures using non-direct contact with a template~~ is a side view of template positioned over a substrate for electric field based lithography;

Paragraph beginning on page 6, line 9.

Fig. 4 ~~depicts a substrate holder configured to alter the planarity of the substrate~~ is a side view of a process for forming nanoscale structures using direct contact with a template; ~~and~~

Paragraph beginning on page 6, line 11.

Fig. 5 ~~depicts an apparatus for positioning a template over a substrate.~~ is a side view of a process for forming

nanoscale structures using non-direct contact with a template;

On page 6, following the description of Fig. 5, insert the following paragraphs.

--Fig. 6 is a side view of a substrate holder configured to alter the planarity of the substrate; and

Fig. 7 is a side view of an apparatus for positioning a template over a substrate.--

After the section entitled DETAILED DESCRIPTION OF THE INVENTION, insert the following paragraphs.

--Figures 1A thru 1E illustrate an imprint lithography process according to the invention, denoted generally as 10. In Figure 1A, a template 12 is orientated in spaced relation to a substrate 14 so that a gap 16 is formed in the space separating template 12 and substrate 14. A surface 18 of template 12 is treated with a thin layer 20 that lowers the template surface energy and assists in separation of template 12 from substrate 14. The manner of orientation including devices for controlling of gap 16 between template 12 and substrate 14 are discussed below. Next, in Figure 1B, gap 16 is filled with a substance 22 that conforms to the shape of surface 18. Preferably, substance 22 is a liquid so that it fills the space of gap 16 rather easily without the use of high temperatures and gap 16 can be closed without requiring high pressures.

A curing agent 24, shown in Figure 1C, is applied to template 12 causing substance 22 to harden and assume the

shape of the space defined by gap 16 between template 12 and substrate 14. In this way, desired features 26, shown in Figure 1D, from template 12 are transferred to the upper surface of substrate 14. A transfer layer 28 is provided directly on the upper surface of substrate 14 which facilitates the amplification of features transferred from template 12 onto substrate 14 to generate high aspect ratio features.

In Figure 1D, template 12 is removed from substrate 14 leaving the desired features 26 thereon. The separation of template 12 from substrate 14 must be done so that desired features 26 remain intact without shearing or tearing from the surface of substrate 14.

Finally, in Figure 1E, features 26 transferred from template 12, shown in Figure 1D, to substrate 14 are amplified in vertical size by the action of transfer layer 28, as is known in the use of bi-layer resist processes. The resulting structure can be further processed to complete the manufacturing process using well-known techniques. Figure 2 summarizes the imprint lithography process, denoted generally as 30, of the present invention in flow chart form. Initially, at step 32, course orientation of a template and a substrate is performed so that a rough alignment of the template and substrate is achieved. The advantage of course orientation at step 32 is that it allows pre-calibration in a manufacturing environment where numerous devices are to be manufactured with efficiency and with high production yields. For example, where the substrate comprises one of many die on a

semiconductor wafer, course alignment (step 32) can be performed once on the first die and applied to all other dies during a single production run. In this way, production cycle times are reduced and yields are increased.

Next, at step 34, the spacing between the template and substrate is controlled so that a relatively uniform gap is created between the two layers permitting the type of precise orientation required for successful imprinting. The present invention provides a device and system for achieving the type of orientation (both course and fine) required at step 34. At step 36, a liquid is dispensed into the gap between the template and substrate. Preferably, the liquid is a UV curable organosilicon solution or other organic liquids that become a solid when exposed to UV light. The fact that a liquid is used eliminates the need for high temperatures and high pressures associated with prior art lithography techniques.

At step 38, the gap is closed with fine orientation of the template about the substrate and the liquid is cured resulting in a hardening of the liquid into a form having the features of the template. Next, the template is separated from the substrate, step 40, resulting in features from the template being imprinted or transferred onto the substrate. Finally, the structure is etched, step 42, using a preliminary etch to remove residual material and a well-known oxygen etching technique to etch the transfer layer.

Paragraph beginning on page 6, line 22.

~~Recently~~ As mentioned above, recent imprint lithography techniques with UV curable liquids [2, 3, 4, 5] and polymers [6] have been described for preparing nanoscale structures. These techniques may potentially be significantly lower cost than optical lithograph techniques for sub-50 nm resolution. Recent research [7,8] has also investigated the possibility of applying electric fields and van der Waals attractions between a template that possesses a topography and a substrate that contains a polymeric material to form nanoscale structures. This research has been for systems of polymeric material that may be heated to temperatures that are slightly above their glass transition temperature. These viscous polymeric materials tend to react very slowly to the electric fields (order of several minutes) making them less desirable for commercial applications.

Paragraph beginning on page 8, line 28.

Figure ~~1~~ 3 depicts an embodiment of the template and the substrate designs. ~~The template~~ Template 12 may be formed from a material that is transparent to activating light produced by curing agent 24 to allow curing of ~~the~~ substance 22, with substance 22 being a polymerizable composition, by exposure to activating light. Forming ~~the~~ template 12 from a transparent material may also allow the use of established optical techniques to measure ~~the~~ gap 16 between template 12 and substrate 14 and to measure overlay marks to perform overlay alignment and magnification correction during formation of the structures. ~~The template~~ Template 12 may also be thermally and mechanically stable to provide nano-resolution patterning capability.

~~The template~~ Template 12 may also include an electrically conducting material to allow electric fields to be generated at the template-substrate interface.

Paragraph beginning on page 9, line 9.

In one embodiment, depicted in Figure ~~1~~ 3, a thick blank of fused silica has been chosen as the base material for ~~the~~ template 12. Indium Tin Oxide (ITO) may be deposited onto the fused Silica. ITO is transparent to visible and UV light and is a conducting material. ITO may be patterned using high-resolution e-beam lithography. ~~A low surface energy coating~~ Thin layer 20 (for example, a fluorine containing self-assembly monolayer) may be coated onto ~~the~~ template 12 to improve the release characteristics between ~~the~~ template 12 and ~~the polymerized composition~~ substance 22. ~~The substrate~~ Substrate 14 may include standard wafer materials such as Si, GaAs, SiGeC and InP. A UV curable liquid may be used as ~~the polymerizable composition~~ substance 22. ~~The polymerizable composition~~ Substance 22 may be spin coated onto ~~the wafer~~ substrate 14. An optional transfer layer 28 may be placed between ~~the wafer~~ substrate 14 and ~~the liquid layer~~ transfer layer 28. ~~This transfer~~ Transfer layer 28 may be used for bi-layer process. ~~The transfer~~ Transfer layer 28 material properties and thickness may be chosen to allow for the creation of high-aspect ratio structures from low-aspect ratio structures created in ~~the cured liquid material~~ substance 22. An electric field may be generated between ~~the~~ template 12 and substrate 14 by connecting the ITO to a voltage source.

Paragraph beginning on page 9, line 23.

In Figures ~~2~~ 4 and ~~3~~ 5, two variants of the above-described process are presented. In each variant, it is assumed that a desired uniform gap 16 may be maintained between ~~the~~ template 12 and ~~the~~ substrate 14. An electric field of the desired magnitude may be applied resulting in the attraction of ~~the polymerizable composition~~ substance 22 towards the raised portions of ~~the~~ template 12. In Figure ~~2~~ 4, ~~the~~ gap 16 and the field magnitudes are such that ~~the polymerizable composition~~ substance 22 makes direct contact and adheres to ~~the~~ template 12. A UV curing process may be used to harden ~~the liquid~~ substance 22 in that configuration. Once the structures have been formed, ~~the~~ template 12 is separated from ~~the~~ substrate 14 by either increasing ~~the uniform~~ gap 16 till the separation is achieved, or by initiating a peel and pull motion wherein ~~the~~ template 12 is peeled away from ~~the~~ substrate 14 starting at one edge of ~~the~~ template 12. Prior to its use, ~~the~~ template 12 is assumed to be treated with ~~a low surface energy monolayer~~ thin layer 20 that assists in the separation step.

Paragraph beginning on page 10, line 6.

In Figure ~~3~~ 5, ~~the~~ gap 16 and the field magnitudes are chosen such that ~~the liquid~~ substance 22 achieves a topography that is essentially the same as that of ~~the~~ template 12. This topography may be achieved without making direct contact with ~~the~~ template 12. A UV curing process may be used to harden ~~the liquid~~ substance 22 in

that configuration. In both the processes of Figures ~~2~~ 4 and ~~3~~ 5, a subsequent etch process may be used to eliminate the residual layer of the UV cured material. A further etch may also be used if ~~a~~ transfer layer 28 is present between ~~the UV cured material~~ substance 22 and ~~the wafer~~ substrate 14 as shown in Figures ~~2~~ 4 and ~~3~~ 5. As mentioned earlier, ~~such a~~ transfer layer 28 may be used to obtain high-aspect ratio structures from a low aspect ratio structure created in ~~the UV cured material~~ substance 22.

Paragraph beginning on page 10, line 15.

~~Figures 4~~ Figure 6 illustrates mechanical devices that may increase the planarity of the substrate. The template may be formed from high-quality optical flats of fused-silica with Indium Tin Oxide deposited on the fused silica. Therefore, the template typically possess extremely high planarity. The substrates typically have low planarity. Sources of variations in the planarity of the substrate include poor finishing of the back side of the wafer, the presence of particular contaminants trapped between the wafer and the wafer chuck, and wafer distortions caused by thermal processing of the wafer. In one embodiment, the substrate may be mounted on a chuck whose top surface shape may be altered by a large array of piezoelectric actuators. The chuck thickness may be such that accurate corrections in surface topography of up to a few microns may be achieved. The substrate may be mounted to the chuck such that it substantially conforms to the shape of the chuck. Once the substrate is loaded on to the chuck, a sensing system (e.g., an optical surface topography measurement

system) may be used to map the top surface of the substrate accurately. Once the surface topology is known, the array of piezoelectric actuators may be actuated to rectify the topography variations such that the upper surface of the substrate exhibits a planarity of less than about 1μm. Since the template is assumed to be made from an optically flat material, this leads to template and substrate that are high quality planar surfaces.

Paragraph beginning on page 11, line 4.

The mechanical device in Figure ~~5~~ 7 may be used to perform a high-resolution gap control at the template-substrate interface. This device may control two tilting degrees of freedom (about orthogonal axes that lie on the surface of the template) and the vertical translation degree of freedom of the template. The magnitude of the gap between the template and the substrate may be measured in real-time. These real-time measurements may be used to identify the corrective template motions required about the tilting degrees of freedom and the vertical displacement degree of freedom. The three gap measurements may be obtained by using a broadband optical interferometric approach that is similar to the one used for measuring thicknesses of thin films and thin film stacks. This approach of capacitive sensing may also be used for measuring these three gaps.

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